GROWTH EFFICIENCY IN JUVENILE MANTIDS: ABSENCE OF SELECTION FOR OPTIMIZATION IN A FOOD-LIMITED ENVIRONMENT (ORTHOPTERA: MANTIDAE)

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Abstract. — First instar mantids, *Tenodera aridifolia sinensis* (Saussure), were offered prey at six different densities in a replicated laboratory experiment. Although predation rate consistently increased with increasing prey density, growth efficiency reached a peak (58%) at intermediate prey density, and declined to 40% at the highest prey density. This decline, which represents a decrease in assimilation efficiency at the most rapid feeding rates, depicts wastage of food and reflects the lack of selection for optimization in food limited environments.

Key Words: predation rate, prey density, growth efficiency, feeding rates.

The Chinese mantid, *Tenodera aridifolia sinensis* (Saussure), is a generalist arthropod predator which inhabits a wide variety of early successional habitats in Delaware and much of the eastern United States (Gurney 1950, Hurd and Eisenberg 1989). Egg hatch typically occurs early in the spring when prey availability for first instar nymphs is low (Hurd 1988). Most mortality occurs during the first stadium, chiefly as a result of food limitation (Hurd and Eisenberg 1984).

Hurd and Rathet (1986) addressed the question of whether, in view of heavy selection against the first stadium, mantid nymphs could optimize predation rate (functional response) to achieve maximum development rate and size at first ecdysis under a variety of prey densities in the laboratory. We found that nymphs which successfully completed the first stadium increased predation rate beyond that which produced gains in both of these life history parameters, an apparently wasteful strategy. Here I examine growth efficiencies for man-

tids in that experiment to clarify how nymphs fed at rates beyond their ability to benefit from increasing prey densities.

MATERIALS AND METHODS

An experimental cohort of *T. a. sinensis* nymphs was derived from oothecae collected in New Castle County, Delaware (Hurd and Rathet 1986). Nymphs were maintained individually in 130 ml glass vials, beginning immediately upon hatching. These were divided into six treatment groups, representing different prey densities, consisting of 20 nymphs each. Densities of prey (*Drosophila melanogaster* Meigen) were established by varying the rate of supply among groups: group I = 0.33 flies/day (one fly every three days), group II = 0.50 flies/day, group III = 1.0 fly/day, group IV = 2.0 flies/day, group V = 3.0 flies/day, and group VI = ad libitum (flies were added in excess of depletion). These mantids were kept in incubators at 23°C on a 12:12 L:D light cycle.

Numbers of flies consumed, whole or in

Table 1.   Mean (±SE) predation rate (flies/mantid/day), dry weight biomass at ecdysis, and dry weight biomass of prey eaten during first stadium for *T. sinensis* nymphs in six experimental groups.

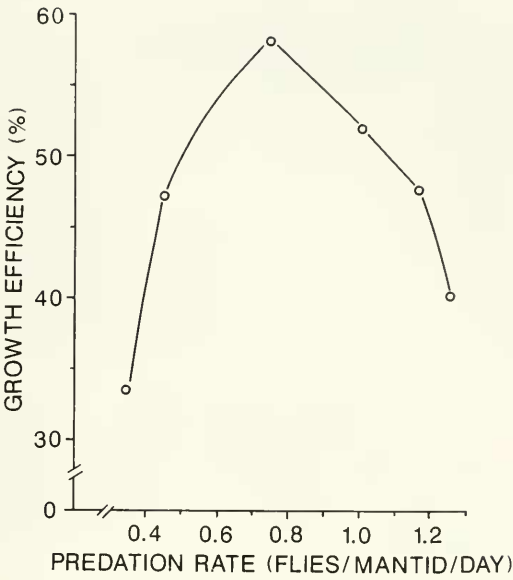| Group	Predation Rate	Ecdysis (mg)	Prey (mg)
I	0.32 (0.01)	1.76 (0.04)	1.97 (0.34)
II	0.45 (0.01)	2.09 (0.04)	2.10 (0.17)
III	0.75 (0.02)	2.72 (0.07)	2.79 (0.15)
IV	1.03 (0.07)	3.01 (0.08)	3.69 (0.28)
V	1.17 (0.04)	2.92 (0.09)	3.81 (0.26)
VI	1.26 (0.06)	2.77 (0.08)	4.17 (0.31)

Fig. 1.   Gross growth efficiency for six experimental groups of first instar *T. sinensis* nymphs as a function of predation rate (calculated from data in Table 1).

part, were counted for each mantid. The total number of flies for each nymph, multiplied by a predetermined standard mean dry weight/fly (0.2 mg), was used as a measure of dry weight biomass of food consumed during first stadium. Dry weight biomass of each nymph was determined upon ecdysis which, combined with the weight of the exoskeleton cast, was compared to a predetermined standard dry weight of newly hatched nymphs (1.10 mg) to determine gain in dry weight biomass over the stadium. This gain, when divided by biomass of food eaten and subsequently multiplied by 100%, is a measure of gross growth efficiency for each nymph.

RESULTS

While feeding rates and total biomass consumed consistently increased with increasing prey density over the six experimental groups, biomass of nymphs at ecdysis did not (Table 1). The resultant growth efficiencies describe a roughly parabolic curve in which maximum efficiency is reached at intermediate predation rate in group III (Fig. 1); i.e. a 42% increase in biomass of food consumed (from group I to group III, Table 1) resulted in a 73% increase in growth efficiency (Fig. 1), whereas a subsequent increase of 49% in biomass eaten (from group III to group VI, Table 1) resulted in a 31% decrease in growth efficiency (Fig. 1).

DISCUSSION

In this experiment increased feeding rate beyond that afforded by intermediate prey density constituted wastage of prey biomass. Size of nymphs at ecdysis and rate of development did not increase past intermediate prey density (Hurd and Rathet 1986) because growth efficiency decreased. It is most likely that assimilation efficiency was reduced at higher prey densities as a result of moving food through the gut too fast for optimal absorption (Slansky and Scriber 1985). In any case, selection has not optimized feeding rate in *T. a. sinensis* nymphs.

The early life history strategy of *T. a. sinensis* has been shaped by an environment depauperate in prey. Selection has therefore favored maximization, rather than optimization, of predation rate simply because the organism does not experience excess prey in the wild. It therefore seems unlikely that mantids, although capable of learning in laboratory situations (Gelperin 1968, Bartley 1983), are able in nature to exercise te-

nets of optimal foraging theory, such as rejecting suboptimal prey (Stephens and Krebs 1986). Most studies of the relationship of various arthropod predators to their prey sources have revealed some degree of food limitation (e.g. Mukerji and LeRoux 1969, Lawton 1971, Wise 1975, 1979, Takafuji and Chant 1976, Formanowicz 1982, Lenski 1984, Folsom and Collins 1984). Therefore in the real world such predators generally may provide poor fit to optimization models.

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